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Rolling in the deep: Priming effects in earthworm biopores in topsoil and subsoil

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ABSTRACT

Priming effect is the change of soil organic matter (SOM) decomposition due to the addition of labile carbon (C) sources. Earthworms incorporate organic matter into their burrow-linings thereby creating preferred habitats for microorganisms, but the roles of such burrows in priming effect initiation is unknown. Here we study the mechanisms driving SOM decomposition in top- and subsoil biopores and additionally in the rhizosphere. Given the topsoil was newly formed after ploughing 10 months prior to sampling, we hypothesized that (1) SOM accessibility, enzyme activities and efficiency of enzymatic reaction (K_a) are main drivers of different priming effect in biopores vs. bulk soil and rhizosphere, subsoil vs. topsoil and (2) the production of microbial enzymes in biopores depends on microbial community composition. To test these hypotheses, biopores formed by *Lumbricus terrestris* L. and bulk soil were sampled from topsoil (0–30 cm) and two subsoil depths (45–75 and 75–105 cm). Additionally, rhizosphere samples were taken from the topsoil. Total organic C (C_{org}), total N (TN), total P (TP) and enzyme activities involved in C-, N-, and P-cycling (cellobiohydrolase, β-glucosidase, xylanase, chitinase, leucine aminopeptidase and phosphatase) were measured. Priming effects were calculated as the difference in SOM-derived CO_2 from soil with or without ^{14}C-labeled glucose addition.

Enzyme activities (V_{max}) and the catalytic efficiency (K_a) were higher in biopores compared to bulk soil and the rhizosphere, indicating that the most active microbial community occurred at this site. Negative correlations between some enzymes and C:N ratio in bulk soil are explained by higher content of fresh organic C in the topsoil, and the corresponding C and nutrient limitations in the subsoil. The positive correlation between enzyme activities and Corg or TN in biopores, however, was associated with the decrease of C and TN with pore age in the subsoil. In the subsoil, priming effect in biopores was 2.5 times higher than bulk soil, resulting from the favorable conditions for microorganisms in biopores and the stimulation of microbial activities by earthworm mucus. We conclude that earthworm burrows provide not only the linkage between top- and subsoil for C and nutrients, but strongly increase microbial activities and accelerate SOM turnover in subsoil, contributing to nutrient mobilization for roots.

1. Introduction

The earthworm *Lumbricus Terrestris* L. is an anecic species inhabiting one single vertical burrow (drilosphere) throughout its entire life (Don et al., 2008), transporting fresh plant detritus from the soil surface downwards while mixing it with mineral soil particles (Lee, 1985; Brown et al., 2000). Earthworms alter soil structure (Lavelle, 1997), distribute litter carbon (C) throughout the entire soil profile (Jégou et al., 2000) and accelerate C turnover over longer time scale (Yavitt et al., 2015). Along burrows, the improved air circulation, enrichment of soil organic matter (SOM) and nutrients, as well as the water retention may reduce or even override the biogeochemical differences between top- and subsoil.

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